PCT/GB 2004 / 0 0 3 1 4 0

The Patent Office

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

REC'D 16 AUG 2004	
WIPO	PCT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

I also certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an amendment, effected by this office, following a request by the applicant and agreed to by the Comptroller-General.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed Stephen Hordley

Dated 10 August 2004

BEST AVAILABLE COPY

Patents Form 1/77

Patents Act 1977
(Rule 16)

THE PATENT OFFICE
L
18 JUL 2003
NEWPORT

The Patent Office

18JUL03 E823560-1 D02973
P01/7700 0.00-0316837.4

The Patent Office

Cardiff Road
Newport
South Wales
NP9 1RH

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference
P102626GB

18 JUL 2003

2. Patent application number
(The Patent Office will fill in this part)
0316837.4

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*
David Richard Hallam
80 Sandy Lane
Leyland
Preston
Lancs PR5 1EE, GB

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

7818081001

4. Title of the invention
Ozone Generating Air Cleaning Device

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

~~Harrison Goddard Foote~~
~~Orlando House~~
~~11c Compstall Road~~
~~Marple Bridge~~
~~Stockport SK6 5HH~~
~~GB~~

Cruikshank & Fairweather
19 Royal Exchange Square
Glasgow
G1 3AE

Patents ADP number *(if you know it)*
547002.
~~145~~ 77002
FS1/77
4/8/04

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

No

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	10
Claim *(s)*	2
Abstract	D
Drawing *(s)*	3 + 3

10. If you are also filing any of the following, state how many against each item.

Priority documents		
Translations of priority documents		
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*		
Request for preliminary examination and search *(Patents Form 9/77)*		
Request for substantive examination *(Patents Form 10/77)*		
Any other documents *(please specify)*	1	Covering letter

11. I/We request the grant of a patent on the basis of this application.

Signature: Harrison Goddard Foote

Harrison Goddard Foote

Date: 17 July 2003

12. Name and daytime telephone number of person to contact in the United Kingdom: David.Garnett 0161 4427 7005

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

Ozone generating air cleaning device

Field of the invention

The present invention relates to an apparatus and method for the removal of impurities such as micro-organisms, smoke particles or odours from air by means of transient exposure of the air to high concentrations of ozone.

Background to the Invention

The use of ozone in many applications involving sterilising and cleaning air is well-known. Ozone generating devices have been designed for a great variety of domestic and industrial applications. All depend on ozone's great oxidising potential to kill micro-organisms and oxidise other organic particles and materials. Depending on the application, ozone is generated by means of ultraviolet radiation or electrical discharge to convert atmospheric oxygen to triatomic ozone, which can be highly effective at destroying organic atmospheric contaminants. Ozone is, however, highly toxic at high concentrations and it is increasingly clear that even at much lower concentrations it is irritant, being particularly linked with asthmatic complaints in those chronically exposed to it. In many territories there are strict statutory limits on the concentration of ozone to which members of the public and employees at a place of work may be exposed. In the UK, the Health and Safety Executive recommendation (EH38) is that the exposure limit to ozone should be 0.1 ppm (0.2 mg m^{-3}) as an 8-hour time-weighted average concentration, with a short-term exposure limit of 0.3 ppm (0.6 mg m^{-3}) as a 15-minute time-weighted average concentration.

Although undoubtedly effective at high concentrations, there is considerable evidence that ozone is ineffective as a biocide or in oxidising organic contaminants at concentrations that are safe for chronic human exposure (Dyas et al, 1983, J Clin Pathol 36: 1102–1104; Berrington and Pedlar, 1998, J Hosp Infect 40: 61–65; Esswein et al, 1994, Appl Occup Environ Hygiene 9: 139–146).

Such effect as it has in reducing odours is, in many cases, probably a mere masking with its own characteristic smell.

Alternative approaches to removing micro-organisms and other small airborne organic particles, such as smoke, obviously include direct filtration of the air. Various type of filter including so-called High Efficiency Particulate Air (HEPA) filters (defined as removing 99.97% of particles of 0.3 micron size) and electrostatic filters capable of similar performance are commonly used. Although effective in some situations, such filters suffer from the disadvantages that trapped (and potentially infective) material remains on the filters, necessitating frequent changes of filter and remaining a hazard until the filters are replaced. This is a particular problem where the air being filtered is humid. In addition, such filters are incapable of removing small viral particles.

There remains a need for an efficient means of removing organic particles, micro-organisms and odours from air without release of potentially hazardous levels of ozone into an enclosed environment.

Summary of the invention

The current invention concerns a method of using high levels of ozone to effective sterilise air of micro-organisms or oxidise organic airborne contaminants and particles in such a way that the air is only transiently exposed to said high concentrations of ozone and is returned to the environment with the level of ozone reduced to acceptable levels for safe exposure of those living or working in the immediate environment.

It has been found that by means of a suitable ozone generating system within a partially confined volume and drawing a suitable flow of air through said volume, preferably also incorporating one or more filters on the inlet(s) through which the

flow of contaminated air is drawn and/or one or more filters on the outlet(s) through which the treated air is expelled, very high efficiencies of oxidation / sterilisation may be achieved very quickly and with a surprisingly low level of residual ozone emitted.

The apparatus of the invention comprises a means of generating ozone in such a way that it is generated and retained substantially within a confined field.

In this context 'field' means a restricted volume surrounding the ozone generating device. In general, this field is contained within a partially closed containment means such a box, cabinet or casing. It is 'partially closed' in the sense that requires apertures capable of acting as one or more inlet(s) and one or more outlet(s) for a through flow of air that is produced by a suitable means, most conveniently an electrically-driven fan so arranged as to efficiently draw air in through the inlets, through the apparatus and out though the outlets.

The ozone generating means may, in principle, be any of the mechanisms well-known in the art. Ozone is produced as a result electrochemical reactions or of the action of ultraviolet radiation, laser radiation or (most commonly and efficiently) of an electrical discharge on atmospheric oxygen. A very great number of these are known in the scientific and patent prior art (for a review of the patented devices see Miller *et al* "A history of patented methods of ozone production from 1897 to 1997", Valdosta State University, Georgia, USA at www.valdosta.edu/~tmanning/research/ozone/).

In a preferred embodiment, ozone is generated by means of a corona discharge device. In a highly preferred embodiment, this comprises tubular stainless steel gauze electrodes separated by a silica glass dielectric. The purpose of gauze electrodes is to maximise the surface available for the corona discharge and hence ozone generation. However, other factors, such as the effects on the electromagnetic field generated, particularly hysteresis effects relating to the

generation and collapse of the field during the 50Hz cycle of the alternating current, also influence the choice of gauze and the fineness of the mesh. In a preferred embodiment the gauze on the outer electrode is coarser than that of the inner electrode as this favours the production of ozone on the outer, rather than inner, electrode. In a more preferred embodiment, the mesh count of the inner electrode is between 50 to 30 x 45 to 25 (per inch or 25.4 mm) and that of the outer electrode is 35 to 20 x 40 to 20. In a particularly favoured embodiment, the mesh count of the inner electrode is 40 x 34 (per inch or 25.4 mm) and that of the outer electrode is 24 x 28.

Preferably the glass is tubular with a wall thickness of between approximately 0.70mm and 1.75mm, and more preferably between 0.8 and 1.1 mm, in order to withstand the stresses of the discharges and to have suitable dielectric qualities. It is also advantageous if the glass is a high quality quartz silicate with added titanium dioxide.

Power to provide a suitable ozone-generating corona discharge is provided by a transformer providing a high-voltage alternating current. In a preferred embodiment the corona discharge device runs very efficiently at a relatively low power. The voltage is preferably between 3 and 4.5kV, more preferably approximately 4.1kV at about 10mA, so that the corona discharge unit consumes between about 3 and 5W, preferably about 4W.

Ozone generation occurs during the negative half cycle of the alternating current, at each electrode in turn. During the corresponding positive half cycle there is a tendency for resident ozone to be broken down, but this is a slower process than generation, and in any case the flow of air removes ozone from the corona discharge area as it is formed. This leads to a net production of ozone. The electrochemistry of such methods of ozone production is known in the art.

Ozone thus generated spontaneously breaks down. The half-life in air is temperature- and concentration-dependent but is in the order of days. However, this half-life is significantly shortened by humidity and by the presence of oxidisable substrates, solid surfaces and specific catalysts. In the presence of a complex arrangement of such "wall effects" and other catalytic factors the actual rate of ozone decomposition is largely unpredictable. The generation of ozone in this way in a confined field, in such a way that it rapidly decomposes beyond the field is referred to by the applicants as "closed coupled-field" generation technology.

Air is drawn through the apparatus by means of one or more electrically-driven fans, which may be conveniently mounted within the containment means, preferably at the one or more inlets to produce an efficient throughput of air. The rate of air flow through the apparatus is not critical, but in a preferred embodiment is of the order of between 50 and 500 m^3h^{-1}. More preferably it is in the order of 150 to 250 m^3h^{-1}. For applications where a greater air flow is required, it will be appreciated that further fans may be fitted and a greater number and area of inlets provided.

In situations where the main use of the apparatus is the removal of smoke particles, it is preferred that the burden of particles passing into the ozone field is reduced by the presence of a pre-filter on the inlets to the containment means surrounding the ozone field. Where the apparatus is used to remove micro-organisms from air that is largely free of high levels of other contaminants, the preferred configuration is the provision of a post-filter on the outlet of the apparatus. In a preferred embodiment this post-filter is an electrostatic filter.

Electrostatic filters are well-known in the art. In principle, they use charged filter media to trap charged particles. Most small units are passive in that they use the friction due to the passage of air through the filter to generate a static charge on specialised materials, although large industrial electrostatic precipitators (or

'electronic' filters) use charged plates or a corona discharge to actively impart charge to airborne particles.
Without being bound by any particular theory or model, it is possible that the combination of the ozone generating unit as described combined with an electrostatic post-filter may provide a particular synergistic benefit, with the filter materials, optionally including surface active materials such as activated charcoal and further optionally including trapped organic material, providing extra catalytic surfaces promoting decomposition of ozone.

Accordingly, the invention provides an apparatus for the cleaning of air comprising a means of generating and retaining ozone within a confined field and a means of drawing a flow of air through said field, wherein said field comprises a concentration of ozone sufficient to effectively oxidise airborne organic material but wherein the concentration of ozone in the cleaned air expelled from said apparatus is within safe limits for a confined environment. Preferably the concentration of ozone 1 metre from the apparatus after 15 minutes of operation is less than 0.3 ppm, more preferably it is less than 0.1 ppm.

In one preferred embodiment, ozone is generated by means of a corona discharge unit, preferably one that comprises tubular metal gauze electrodes separated by a silica glass dielectric. More preferably, the silica glass contains a proportion of titanium. Further preferably the corona discharge unit runs at a voltage of less than 5kV and consumes less than 500W.

It is also preferred that apparatus comprises an ozone-containing field that is confined within a partially closed containment means. Further preferably said containment means has defined inlets and outlets to allow a through flow of air. In a most preferred embodiment said inlets and/or outlets are fitted with one or more filters.

In one aspect of the invention, the apparatus is one wherein air is cleaned of micro-organisms. Preferably said apparatus comprises one or more outlets that are fitted with one or more filters, most preferably electrostatic filters.

In another aspect, the invention provides a method of cleaning air comprising generating and retaining ozone within a confined field, wherein said field comprises a concentration of ozone sufficient to effectively oxidise airborne organic material and drawing a flow of air through said field, such that the cleaned air having passed through said field contains a concentration of ozone that is within safe limits for a confined environment. In one preferred embodiment, air is cleared of viable airborne micro-organisms and passes through a filter after exposure to ozone. More preferably, this filter is an electrostatic filter.

The invention also provides a method of increasing the usefulness of filters, particularly filters designed to remove airborne micro-organisms. Such filters require to be replaced or cleaned as organic particles and / or micro-organisms are deposited on them. Where such filters are also bathed in ozone-enriched air, this has the effect of oxidising such trapped organic particles and micro-organisms with the result that the effective life of the filter is increased and micro-organisms destroyed. The corollary of this effect is any remaining ozone passing through the filter is efficiently broken down as it oxidises the organic material trapped there. This effect is increased by the intrinsic catalytic effect of filter components on the decomposition of ozone. In this way, the combination of highly efficient filters, such as HEPA or electrostatic filters capable of effectively removing particles as small as 0.3 microns, and bacteriocidal concentrations of ozone in the air being filtered is synergistic, with an increased benefit over that obtained over either alone, in terms of prolonged efficient filtering and killing of potentially infectious micro-organisms.

In a further aspect of the invention, the apparatus is one wherein air is cleaned of smoke particles. Preferably, said apparatus comprises one or more inlets that are fitted with one or more filters.

Also provided is method of cleaning air comprising generating and retaining ozone within a confined field, wherein said field comprises a concentration of ozone sufficient to effectively oxidise airborne organic material and drawing a flow of air through said field, such that the cleaned air having passed through said field contains a concentration of ozone that is within safe limits for a confined environment, wherein air is cleared of smoke particles and wherein air passes through a filter before exposure to ozone.

Detailed description of the invention

Brief description of the drawings

The invention will now be described in detail, with reference to the following drawings.

Figure 1 shows a schematic cross-section of an apparatus for the removal of micro-organisms from air according to the invention. 1 indicates the casing, 2 the inlet, 3 the fan, 4 an optional pre-filter, 5 the transformer, 6 the corona discharge unit, 7 the outlet, 8 the electrostatic post-filter.

Figure 2 shows the construction of the corona discharge ozone-generating unit. 1 is the glass tube dielectric, 2 the outer mesh electrode, 3 the inner mesh electrode fitted with a spade end electrical connector (4). When constructed the outer mesh is rolled into a tube with a flange (5) providing a fixing means. 6 is an insulating plastic plate locating the assembly by means of insulating screws (7) nuts and washers (8).

Figure 3 shows a perspective view of one embodiment of the invention showing a casing for a model with four apertures for fans.

Example 1. An apparatus for the removal of micro-organisms from air

Construction

With reference to Figure 1, the apparatus comprises a containment means consisting of a casing (1), in this case of thin sheet metal construction. This casing has an inlet (2) fitted with an electrically-driven fan (3) so positioned as to produce an efficient flow of air into the apparatus. The inlet may, optionally, have a pre-filter (4) fitted. Within the casing is an approximately 4W corona discharge unit (6) operating at approximately 4kV and 10mA. A transformer (5) supplies power to the corona discharge unit. In this case the outlet (7) is fitted with an electrostatic post-filter (8, HAF, 3M Corporation)

The details of the construction of the corona discharge unit are shown in Figure 2. A silica glass tube dielectric (1) with a wall thickness of 0.8–1.1mm has outer (2) and inner (3) essentially tubular stainless steel gauze electrodes. The dimensions are not critical but in this case the glass tube is approximately 63 mm long, inner electrode is formed from a 40 x 34 mesh number gauze of approximately 71 x 63mm, and the outer electrode is formed from a coarser 24 x 28 mesh number gauze of approximately 133 x 63mm. The inner electrode fits within the glass tube and is fitted with a spade end electrical connector (4). The outer electrode is formed into a cylinder fitting around the glass tube with a flange (5) allowing it to be fixed, together with the glass tube and inner electrode assembly, to a suitable insulating plastic base plate (6) by means of insulating nylon screws (7) and washers and nuts (8).

Figure 3 shows a casing suitable for use as a containment means as described above. By configuring fans appropriately, air may by drawn in through the louvred apertures and out through the circular apertures, optionally though a post-filter. This arrangement is particularly suitable for use in an apparatus for the removal of micro-organisms from air.

Figure 3 shows a perspective view of one embodiment of the invention showing a casing for a model with four apertures for fans.

Example 1. An apparatus for the removal of micro-organisms from air

Construction

With reference to Figure 1, the apparatus comprises a containment means consisting of a casing (1), in this case of thin sheet metal construction. This casing has an inlet (2) fitted with an electrically-driven fan (3) so positioned as to produce an efficient flow of air into the apparatus. The inlet may, optionally, have a pre-filter (4) fitted. Within the casing is an approximately 4W corona discharge unit (6) operating at approximately 4kV and 10mA. A transformer (5) supplies power to the corona discharge unit. In this case the outlet (7) is fitted with an electrostatic post-filter (8, HAF, 3M Corporation)

The details of the construction of the corona discharge unit are shown in Figure 2. A silica glass tube dielectric (1) with a wall thickness of 0.8–1.1mm has outer (2) and inner (3) essentially tubular stainless steel gauze electrodes. The dimensions are not critical but in this case the glass tube is approximately 63 mm long, inner electrode is formed from a 40 x 34 mesh number gauze of approximately 71 x 63mm, and the outer electrode is formed from a coarser 24 x 28 mesh number gauze of approximately 133 x 63mm. The inner electrode fits within the glass tube and is fitted with a spade end electrical connector (4). The outer electrode is formed into a cylinder fitting around the glass tube with a flange (5) allowing it to be fixed, together with the glass tube and inner electrode assembly, to a suitable insulating plastic base plate (6) by means of insulating nylon screws (7) and washers and nuts (8).

Figure 3 shows a casing suitable for use as a containment means as described above. By configuring fans appropriately, air may by drawn in through the louvred apertures and out through the circular apertures, optionally though a post-filter. This arrangement is particularly suitable for use in an apparatus for the removal of micro-organisms from air.

Performance

This unit has been tested for efficiency in microbiological tests for killing of airborne bacteria and fungal (*Aspergillus niger*) spores and found to kill >95% at a flow rate of about 150 m^3h^{-1}.

The output of ozone has also been tested and been found to be within the EH38 guidelines.

Example 2. An apparatus for the removal of smoke particles from air
Alternatively, apparatus based in the casing shown in Figure 3 may be configured for the efficient removal of smoke from air. In this embodiment the fans may be so arranged as to draw air in through the circular apertures, optionally through a pre-filter, through the field of high ozone concentration and out through the louvred apertures shown. It is particularly suitable for use in public areas such as public houses, hotels and bars. Preferably, in this case the inlet is fitted with a pre-filter. The core components of fan, corona discharge unit and fan are common with the apparatus of Example 1.

Example 3. Odour-removing apparatus
It will be apparent that the principle of drawing air through a field of high ozone concentration sufficient to oxidise many organic pollutants is equally applicable to the removal of unpleasant or unwanted odours, where these are caused by compounds capable of being oxidised to odourless products. The apparatus of the invention, optionally fitted with pre- and/or post-filters, preferably containing activated charcoal is highly suitable for this purpose.

Claims

1. An apparatus for the cleaning of air comprising a means of generating and retaining ozone within a confined field and a means of drawing a flow of air through said field, wherein said field comprises a concentration of ozone sufficient to effectively oxidise airborne organic material but wherein the concentration of ozone in the cleaned air expelled from said apparatus is within safe limits for a confined environment.

2. The apparatus of Claim 1 wherein ozone is generated by means of a corona discharge unit.

3. The apparatus of Claim 2 wherein the corona discharge unit comprises tubular metal gauze electrodes separated by a silica glass dielectric.

4. The apparatus of Claim 3 wherein the corona discharge unit runs at a voltage of less than 5kV and consumes less than 500W.

5. The apparatus of any one of Claims 1–4 wherein the field is confined within a partially closed containment means.

6. The apparatus of Claim 5 wherein the containment means has defined inlets and outlets to allow a through flow of air.

7. The apparatus of Claim 6 wherein said inlets and/or outlets are fitted with one or more filters.

8. The apparatus of any one of Claims 1–7 wherein air is cleaned of micro-organisms.

9. The apparatus of Claim 8 wherein the one or more outlets are fitted with electrostatic filters.

10. A method of cleaning air comprising generating and retaining ozone within a confined field, wherein said field comprises a concentration of ozone sufficient to effectively oxidise airborne organic material and drawing a flow of air through said field, such that the cleaned air having passed through said field contains a concentration of ozone that is within safe limits for a confined environment.

11. The method of Claim 10 wherein air is cleared of viable airborne micro-organisms and wherein air also passes through a filter after exposure to ozone.

12. The method of Claim 11 wherein said filter is an electrostatic filter.

13. The apparatus of any one of Claims 1–7 wherein air is cleaned of smoke particles.

14. The apparatus of Claim 13 wherein the one or more inlets are fitted with filters.

15. The method of Claim 10 wherein air is cleared of smoke particles and wherein air also passes through a filter before exposure to ozone.

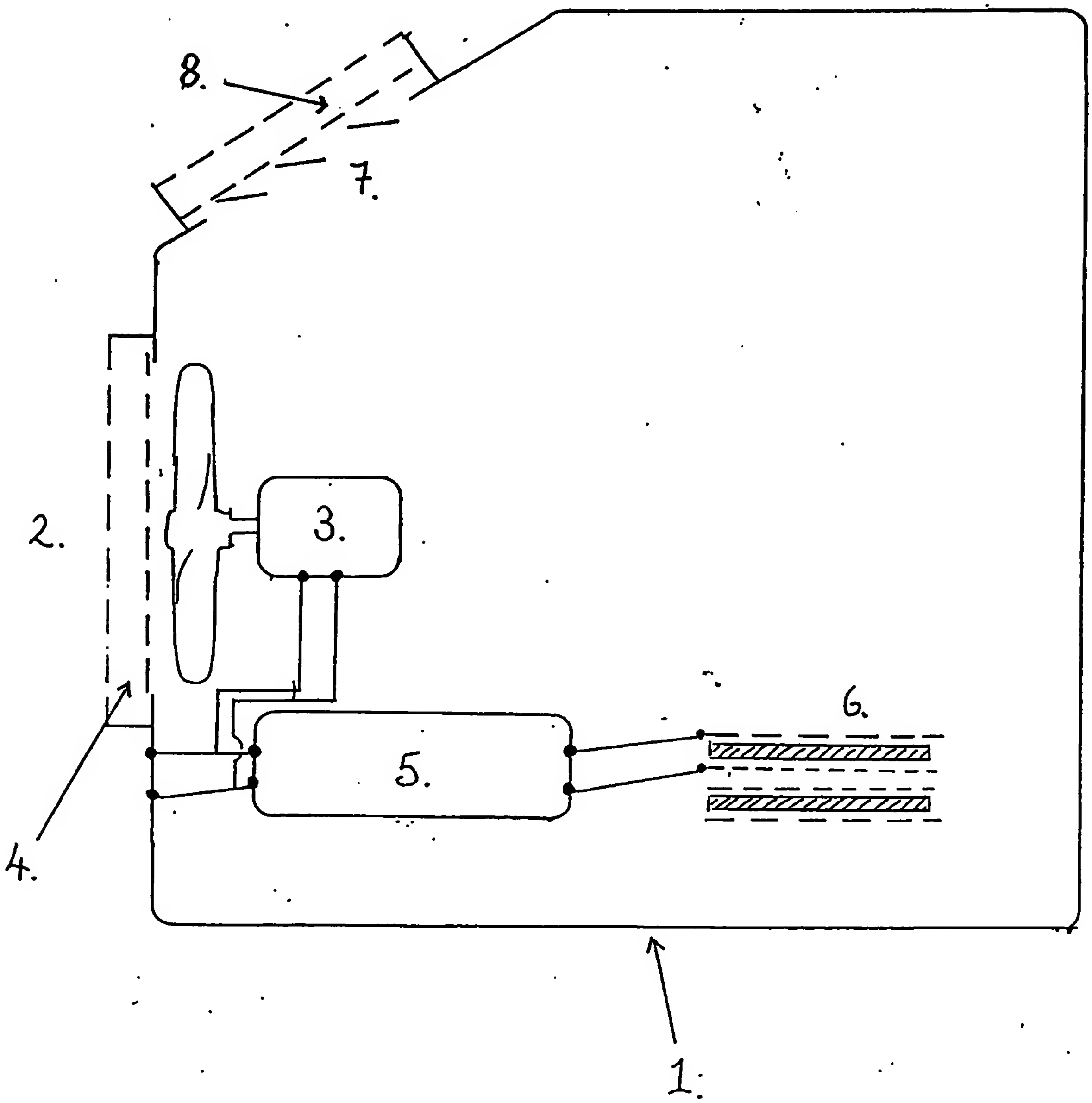
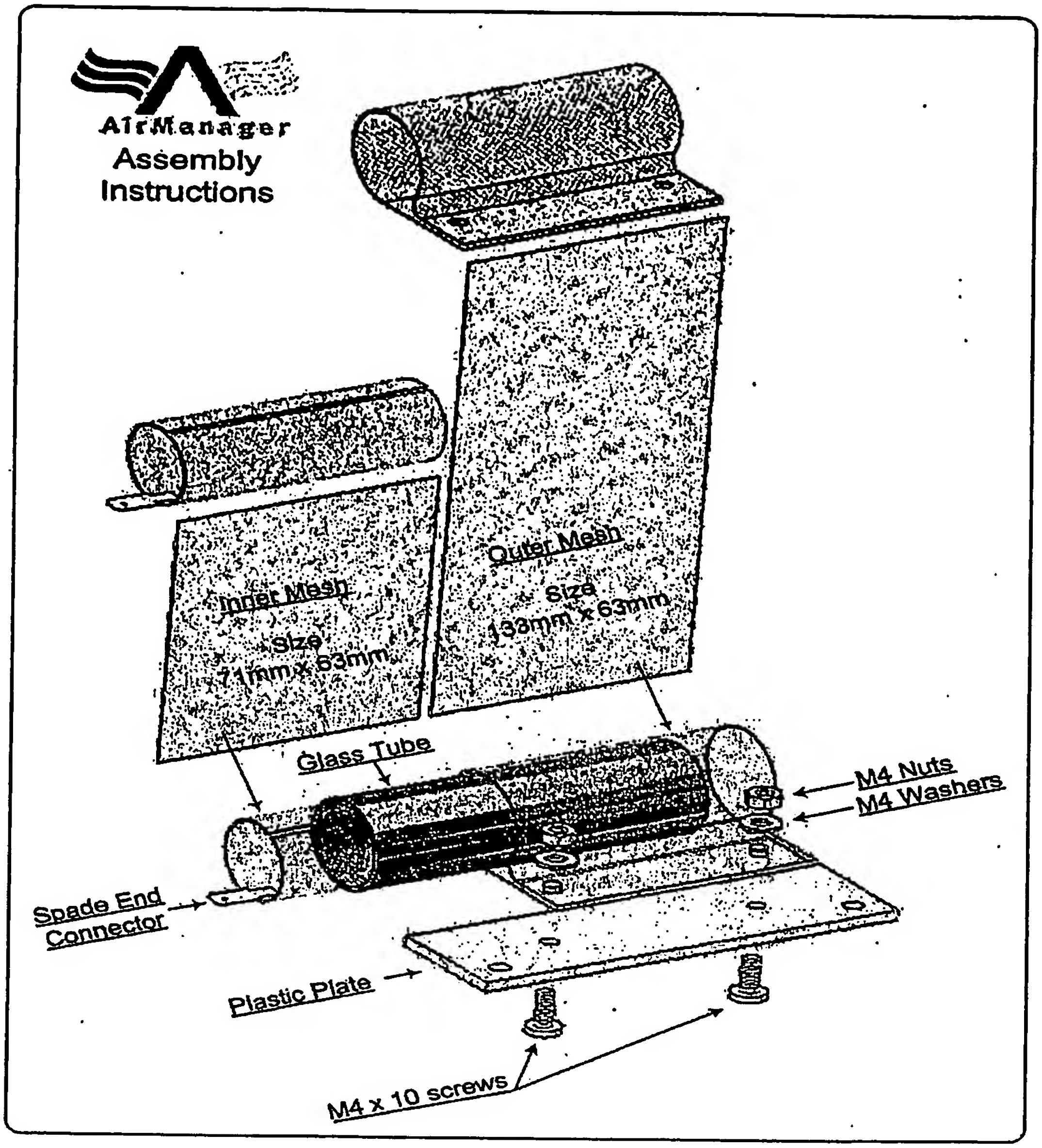


Figure 1



AirManager
Assembly
Instructions
Outer Mesh
Size
133mm x 63mm
Inner Mesh
Size
71mm x 63mm
Glass Tube
M4 Nuts
M4 Washers
Spade End
Connector
Plastic Plate
M4 x 10 screws

Figure 2

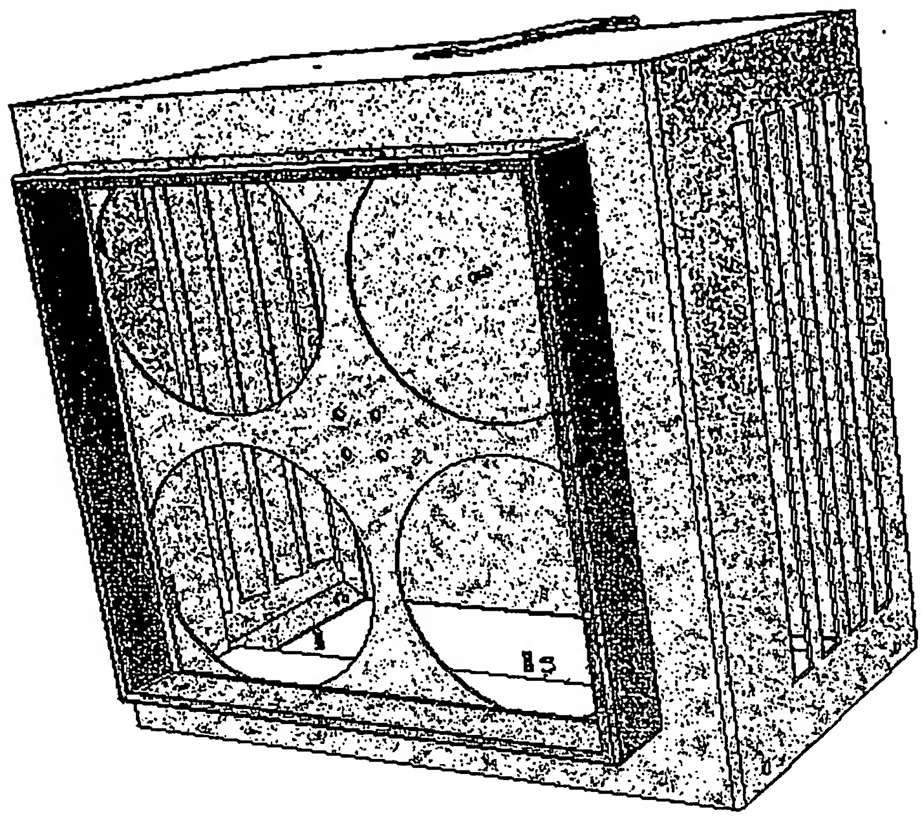


Figure 3